IRON OXIDE PIGMENTS

By Michael J. Potter

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Natural iron oxides are derived from hematite, which is a red iron oxide mineral; limonites, which vary from yellow to brown, such as ochers, siennas, and umbers; and magnetite, which is black iron oxide. Synthetic iron oxide pigments are produced from basic chemicals. The three major methods for the manufacture of synthetic iron oxides are thermal decomposition of iron salts or iron compounds; precipitation of iron salts, usually accompanied by oxidation; and reduction of organic compounds by iron (Podolsky and Keller, 1994, p. 765, 772).

Production

U.S. production data for crude (natural) iron oxide pigments (IOPs) sold or used in 2003 were developed by the U.S. Geological Survey (USGS) from a voluntary survey of four companies, all of which responded (table 1). In a second voluntary survey, data were received from 7 of 12 known operations (58%) for finished (natural and synthetic) IOPs sold by producers, by kind (table 2). By tonnage, the 7 operations represented 43% of the output. In a survey of these same 12 operations for finished IOPs by end use, 4 (33%) responded. The response rate by tonnage was 24% (table 4).

Responses were obtained from two of three canvassed producers of regenerated iron oxide, which is obtained when spent pickle liquor from steelmaking is treated (table 3). Regenerator iron oxide data were not included in tables 1, 2, and 4. A major end use for this material was ferrites, which are magnetic ceramic oxides. There are two types of ferrites—soft, which do not retain permanent magnetism, and hard, which retain permanent magnetism. Uses of soft ferrites include computers, cores for radio frequency (RF) coils, inverter cores, memory cores, microwave communication systems, microwave ferrites for telecommunications, pot cores, rectangular modulus (RM) cores, TV deflection yokes, and other industrial applications (Govila, 1991, p. 2-3). Hard ferrites are used in flexible magnets, generators, loudspeakers, and motors.

Rockwood Pigments NA, Inc. acquired the business and assets of Southern Color Co., Inc. and its affiliates. The new subsidiary, Southern Color N.A., Inc., based in Cartersville, GA, is a major supplier of masonry coloring services, packaged mortar products, and pigments to the construction industry (Rockwood Specialties Group, Inc., 2003). Grace Construction Products finalized a distribution alliance with Rockwood to market Rockwood's Davis Colors brand of automatic dispensing systems and liquid pigments. Davis Colors is the leading U.S. producer of automatic color handling systems and color additives for ready-mix concrete (Grace Construction Products, 2003).

Consumption

Based largely on estimated data, the largest end-use categories for total U.S. IOP output (natural and synthetic) in 2003 were estimated to be construction (27%) and coatings (24%) (table 4). Construction applications included such concrete products as block, brick or segmental retaining wall units, mortar, paving stones, precast products of various sizes or dimensions, ready-mixed concrete, and roofing tiles, (Bayer Corp., 2002§[1]). Shipments of total paint and coatings, comprising architectural coatings, original equipment manufacture product coatings, and special-purpose coatings, increased by 2% in 2003 compared with those of 2002 (U.S. Census Bureau, 2004§).

Prices

Yearend 2003 IOP published prices, which are meant to serve as a general guideline only, converted to dollars per kilogram, in bags, per truckload, free on board warehouse, were black, synthetic, $2.07 per kilogram; buff, natural, domestic, which included dark and light, from $1.16 per kilogram to $2.14 per kilogram; and yellow, synthetic, $2.25 per kilogram to $2.34 per kilogram (Chemical Market Reporter, 2003). The average annual producer price index (PPI) for IOPs for 2003 was 178.1 compared with 178.0 in 2002. The PPI measures the average change over time in the selling prices received by domestic producers of IOPs. The base year for the IOP PPI is June 1983 (U.S. Bureau of Labor Statistics, 2004§).

[1]References that include a section mark (§) are found in the Internet References Cited section.

Foreign Trade

U.S. exports of pigment-grade IOPs in 2003 totaled 4,500 metric tons (t), or 28% less than those of 2002 (table 5). U.S. imports of synthetic IOPs of 136,000 t in 2003 were 8% higher than those of 2002 (table 6). By tonnage, the four largest sources were China with 54%; Germany, 26%; and India and Italy, 4% each (table 7).

World Review

Although official data were not available, data from one nongovernmental source projected a total world production of IOPs of 1.5 million metric tons in 2000 (latest data). China supplied 26%; Western Europe, 25%; India, 22%; Japan, 15%; and the United States, 11% (Will, 2004, p. 7, 12). China has become the largest exporter of IOPs. According to another source, Chinese sales of IOPs in 2003 were 430,000 t, with 239,000 t being exported. The largest recipients were North America with 78,000 t; Europe, 65,000 t; and Southeast Asia, 49,000 t (Gao, 2004, p. 9-10).

Micaceous iron oxide, a platy form of iron oxide, is used largely in Asia, Australia, and Europe in paints and coatings for corrosion prevention. The three largest producing countries, using 2000 data (latest available), were Austria, Morocco, and Australia, in decreasing order of output. Total annual world usage was estimated to be 14,000 t, with Europe consuming about 60%. Applications included bridges, oil refineries, water towers, and other facilities (Spear, 2004, p. 6, 9-10).

In Germany, BASF AG has developed stir-in pigments that are in the form of microgranules. They include five iron oxide grades—opaque red, opaque yellow, a semitransparent red, transparent red, and transparent yellow grades. The pigments can be stirred directly into waterborne systems. Traditional pigments require milling and grinding to color paint properly. Applications of the stir-in pigments include architectural and decorative paints, coloration of plasters and concrete, wood coatings, and other uses (Gonzalez-Gomez, 2004, p. 1, 5, 14).

Outlook

Coatings and construction materials continue to be the largest end users of IOPs. In the paint and coatings industry, major innovations, such as the development of latex and low volatile organic compounds (VOC) paints, are rare. More common are functional innovations that involve adapting existing product features to provide new customer benefits (Koch, 2004, p. 23).

In China, strong competition has resulted in numerous mergers among iron oxide producers. Increased manufacturing costs owing to rising raw material (steel scrap) and fuel costs may result in increased prices for iron oxide. Chinese producers are concentrating on new and improved products and technology (Gao, 2004, p. 13, 14).

In the Western European paint industry, mergers and acquisitions have taken place. Much of the paint market is mature, and companies are looking at export markets, such as Poland, and growth areas, such as Russia and the Ukraine. Also, updated paint technologies and Western formulations could be supplied to Eastern European producers (Industrial Minerals, 2003).

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TABLE 1
SALIENT U.S. IRON OXIDE PIGMENTS STATISTICS[1]

		1999	2000	2001	2002	2003
Crude pigments sold or used:[2]						
Quantity	metric tons	44,100	57,100	61,500	W	W
Value	thousands	$7,740	$4,470	$3,460	$1,070	W
Finished pigments sold:[3]						
Quantity	metric tons	183,000	154,000	135,000	115,000	90,000 [e, 4]
Value	thousands	$187,000	$142,000	$130,000	$117,000	$89,000 [e, 4]
Exports:						
Quantity	metric tons	13,800	9,640	9,100	6,270	4,500
Value	thousands	$15,200	$17,200	$16,800	$12,100	$11,000
Imports for consumption:						
Quantity	metric tons	80,800	91,300	89,900	132,000	140,000
Value	thousands	$71,400	$76,700	$76,900	$96,300	$96,600

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits.
[2]Mined.
[3]Natural (mined) and synthetic.
[4]Data are rounded to two significant digits because they are estimated.

TABLE 2
FINISHED IRON OXIDE PIGMENTS SOLD BY PROCESSORS IN THE UNITED STATES, BY KIND

Kind	2002 Quantity (metric tons)	2002 Value (thousands)	2003 Quantity (metric tons)	2003 Value (thousands)
Natural:				
Black, magnetite	W	W	W	W
Umbers:				
Burnt	1,680	$2,660	W	W
Raw	W	W	2,610	$4,320
Red, iron oxide[1]	W	W	W	W
Undistributed and other[2]	58,300 r	17,900 r	49,900	16,200
Total[3]	60,000	20,600	52,500	20,500
Synthetic:				
Black, iron oxide	W	W	W	W
Brown, iron oxide	W	W	--	--
Red, iron oxide	W	W	W	W
Yellow, iron oxide	19,700	34,900	22,400	39,100
Mixtures of natural and synthetic, iron oxides	W	W	W	W
Total[3]	54,600	96,000	37,100	68,900
Grand total	115,000 [3]	117,000 [3]	90,000 e, 4	89,000 e, 4

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Natural, undistributed and other" and "Synthetic, total." -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes pyrite cinder.

[3]Includes burnt sienna, ocher, raw sienna, and data indicated by symbol W.

[4]Data are rounded to two significant digits because they are estimated.

TABLE 3
PRODUCERS OF IRON OXIDE PIGMENTS AND REGENERATOR IRON OXIDES IN THE UNITED STATES IN 2003

Producers	Plant location
Finished pigments:	
Alabama Pigments Co.	Green Pond, AL.
Bayer Corp.	New Martinsville, WV.
Dynamic Color Solutions, Inc.	Milwaukee, WI.
Elementis Pigments Inc.	East St. Louis, IL; and Easton, PA.
Hoover Color Corp.	Hiwassee, VA.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Prince Manufacturing Co., Inc.	Quincy, IL; and Bowmanstown, PA.
Rockwood Pigments Inc.	Beltsville, MD; and St. Louis, MO.
Solomon Grind-Chem Services Inc.	Springfield, IL.
Crude pigments:	
Alabama Pigments Co.	Green Pond, AL.
Cleveland-Cliffs Iron Co., Mather Mine and Pioneer plant[1]	Negaunee, MI.
Hoover Color Corp.	Hiwassee, VA.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Regenerator iron oxides:	
Bailey-PVS Oxides, L.L.C.	Decatur, AL; Fairfield, AL; Delta, OH.
International Steel Services, Inc.	Allenport, PA.
Weirton Steel Corp.	Weirton, WV.

[1]Closed July 31, 1979; shipping from stockpile.

TABLE 4
ESTIMATED IRON OXIDE PIGMENT CONSUMPTION, BY END USE, AS A PERCENTAGE OF REPORTED SHIPMENTS

End use	All iron oxides		Natural iron oxides		Synthetic iron oxides	
	2002	2003	2002	2003	2002	2003
Coatings (industrial finishes and trade sales coatings--lacquers, paints, varnishes)	22 r	24	14	16	31 r	36
Construction materials (cement, mortar, preformed concrete, roofing granules)	34	27	W	W	W	W
Colorants for ceramics, glass, paper, plastics, rubber, textiles	12	12	W	W	W	W
Foundry sands	W	W	W	W	--	--
Industrial chemicals (such as catalysts)	8	10	W	W	W	W
Other[1]	24 r	27	86	84	69 r	64
Total	100	100	100	100	100	100

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." -- Zero.
[1]Includes animal feed, cosmetics, ferrites, fertilizers, magnetic ink and toner, polishing agents, and data indicated by symbol W.

TABLE 5
U.S. EXPORTS OF IRON OXIDES AND HYDROXIDES, BY COUNTRY[1]

	2002				2003			
	Pigment grade		Other grade		Pigment grade		Other grade	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Australia	171	$389	284	$541	124	$230	222	$366
Belgium	448	1,560	2,160	6,170	487	2,290	205	793
Brazil	13	54	240	303	18	108	238	305
Canada	8	10	13,100	11,200	9	12	11,300	10,700
China	44	119	8,420	1,420	86	146	21,200	2,950
Colombia	54	104	98	95	26	87	147	105
France	4	22	191	262	117	371	132	500
Germany	82	195	1,720	3,260	123	220	340	742
Hong Kong	728	1,870	2,160	3,160	544	1,320	1,100	1,650
India	146	318	197	78	223	431	308	94
Indonesia	2	8	50	108	--	--	214	286
Italy	6	63	1,020	782	5	19	1,080	783
Japan	1,470	1,850	1,640	2,680	12	60	1,340	1,030
Korea, Republic of	1,200	1,710	3,130	1,910	1,080	2,400	1,670	1,350
Malaysia	--	3	147	320	--	--	195	491
Mexico	873	858	1,180	1,830	603	293	1,440	1,720
Netherlands	6	3	760	1,400	2	7	634	1,170
Russia	642	1,530	97	163	536	1,350	241	408
Singapore	21	35	1,650	508	90	216	1,240	759
Taiwan	56	137	1,730	1,480	2	7	1,460	1,070
Thailand	5	13	617	382	23	43	816	451
United Kingdom	31	66	2,990	5,230	74	106	2,560	4,070
Venezuela	8	31	139	80	9	25	39	42
Other	253 r	1,130 r	737 r	1,810 r	304	1,300	632	896
Total	6,270	12,100	44,400	45,100	4,500	11,000	48,800	32,700

rRevised. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF SELECTED IRON OXIDE PIGMENTS, BY TYPE[1]

Type	2002 Quantity (metric tons)	2002 Value[2] (thousands)	2003 Quantity (metric tons)	2003 Value[2] (thousands)	Principal sources, 2003 (metric tons)
Natural:					
Earth colors[3]	2,870	$1,220	3,410	$1,420	Cyprus, 3,360; Germany, 38.
Micaceous	3,160	1,460	591	735	Austria, 314; Spain, 171.
Total	6,020	2,680	4,000	2,150	
Synthetic:					
Black	31,200	31,800	36,500	31,900	Germany, 13,000; China, 11,800; Italy, 3,810 India, 3,740; Japan, 2,190; Mexico, 894; Sweden, 532; Canada, 330; Hong Kong, 113.
Red	52,000	29,900	54,900	30,700	China, 32,800; Germany, 14,700; Hong Kong, 1,280; India, 1,200; Belgium, 1,070; Sweden, 826; Italy, 725; Canada, 654; Mexico, 498.
Yellow	39,100	26,700	41,600	27,500	China, 26,900; Germany, 7,470; Brazil, 2,790; Mexico, 1,200; Hong Kong, 1,030; Italy, 751; Colombia, 721.
Other[4]	3,440	5,210	2,960	4,370	China, 1,210; Cyprus, 491; Japan, 472; Germany, 346; Canada, 131; Italy, 101.
Total	126,000	93,600	136,000	94,500	
Grand total	132,000	96,300	140,000	96,600	

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Customs value.

[3]Includes those earth colors not elsewhere specified or included.

[4]Includes synthetic brown oxides, transparent oxides, and magnetic and precursor oxides.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF IRON OXIDE AND IRON HYDROXIDE PIGMENTS, BY COUNTRY[1]

	Natural				Synthetic			
	2002		2003		2002		2003	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Austria	267	$239	314	$321	--	--	--	--
Belgium	1,050	305	--	--	74	$306	1,160	$791
Brazil	--	--	--	--	5,230	4,280	2,970	2,570
Canada	(3)	2	--	--	3,120	1,720	1,410	2,100
China	47	27	--	--	68,200	33,900	72,800	36,100
Colombia	--	--	--	--	812	766	1,070	1,290
Cyprus	2,680	1,100	3,360	1,350	928	349	491	190
France	224	115	38	24	44	427	44	337
Germany	24	24	38	38	27,100	22,800	35,600	23,200
Hong Kong	--	--	--	--	2,300	1,380	2,490	1,400
India	9	5	5	3	4,050	2,590	5,040	2,790
Italy	--	--	--	--	5,650	5,490	5,390	6,260
Japan	20	14	20	14	3,500	14,300	2,740	12,500
Mexico	19	15	--	--	2,830	2,450	2,610	2,280
Netherlands	1,210	424	--	--	5	2	56	41
Spain	179	70	20	7	408	185	301	136
Sweden	154	40	--	--	990	233	1,360	330
United Kingdom	24	117	23	155	492	2,360	255	1,880
Other	120	181	182	239	38	103	181	180
Total	6,020	2,680	4,000	2,150	126,000	93,600	136,000	94,500

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Customs value.

[3]Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 8

NATURAL IRON OXIDE PIGMENTS: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	1999	2000	2001	2002	2003
Austria	6,000	6,000	5,000	5,000	5,000
Brazil	2,000	2,000	2,000	2,000	2,000
Chile	9,992 [4]	10,000	10,000	10,000	10,000
Cyprus, umber	9,169 [4]	7,500 [4]	4,800 [4]	5,000	5,000
France	1,500	1,500	1,000	1,000	1,000
Germany[5]	4,000	4,000	4,000	4,000	4,000
India, ocher	380,000	336,000	355,000	360,000	365,000
Iran	13,300	13,500	1,000 [r, 4]	2,300 [r, 4]	2,300
Italy	500	500	500	500	500
Pakistan, ocher	3,200	4,747 [4]	4,800	4,500	4,500
Paraguay, ocher	300	300	300	300	300
South Africa	216 [4]	568 [4]	852 [4]	252 [4]	643 [4]
Spain:					
Ocher	70,000	87,000 [4]	87,000	87,000	80,000
Red iron oxide	15,000	--	-- [4]	--	--
United States	44,100 [4]	57,100 [4]	61,500 [4]	W	W

[r]Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1]Estimated data are rounded to no more than three significant digits.

[2]Table includes data available through June 4, 2004.

[3]In addition to the countries listed, a number of others undoubtedly produce iron oxide pigments, but output is not reported, and no basis is available for formulating estimates of output levels. Such countries include Azerbaijan, China, Kazakhstan, Russia, and Ukraine. Unreported output is probably substantial.

[4]Reported figure.

[5]Includes vandyke brown.